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DISTRIBUTION OF NUTRIENTS IN SHATT AL-ARAB ESTUARY.

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ABSTRACT

The seasonal distribution of nutrients in the Euphrates and Tigris estuary (Sahht Al-Arab) was investigated and discussed. The increase in nitrate and nitrite concentrations is due principally to the discharge of sewage and industrial wastes, as well as the waters of the feeding rivers mainly Karun. Very high phosphate concentrations found in some bottom samples coincided with the decay of phytoplankton and the release of phosphate from the sediments, sewage wastes and runoff from cultivated lands. The increase in silicate content, especially in the bottom samples at some locations, is due mainly to the decline of diatoms and the increase in the rate of dissolution of ditom frustules in the sediments. Nonbiological factors seem to greatly affect the content of nutrients in Shatt Al-Arab.

INTRODUCTION

In spite of the great importance of Shatt Al-Arab for Iraq and Iran, particularly for fisheries, household use, agriculture and navigation and its effects on the water characteristics of the Arabian Gulf at the area of discharge, few studies have been carried out on the water of this estuary (Mohammad, 1965 a, b, Al-Saadi and Arndt, 1973, Kell and Saad, 1975, Arndt and Al-Saadi, 1975, Saad and Kell, 1975, Antoine and Shihab, 1977, Saad, 1978, b, 1982, Al-Saadi et al., 1979). The present work deals with the distribution of nutrients in Shatt Al-Arab in order to throw out light on their seasonal variations. These dissolved salts are needed for phytoplankton production and may affect the fertility of the Gulf water mainly near the area of discharg. Shatt Al-Arab is the only fresh water source to the Gulf.

Description of Shatt Al-Arab:

The river Euphrates divides at its lower reaches in Iraq into two branches. One branch joins the river Tigris at the town Qurna forming Shatt Al-Arab. The other branch traverses Hor Hammar, a large marsh enriched with aquatic plants, and then joins Shatt Al-Arab at Sindbad Island. Shatt Al-Arab runs in a south eastern direction to open into the Arabian Gulf.

The river Karun, crossing the Persian lands, opens into Shatt Al-Arab at about 20 km north of Abadan (Fig. 1). Shatt Al-Arab transports annually to the gulf about 35300 million m of fresh water (SAAD, 1978 a). The inflowing water may reach a distance of about 5 km inside the Gulf. Hundreds of outlets, in the form of small rivers and canals, are found on both sides of Shatt Al-Arab. Four of these cross the city of Basrah and highly polluted by sewage and agricultural wastes. The polluted waters of these canals and probably of the other lateral channels enter into Shatt Al-Arab twice daily during the ebb. The pollutants accumulated in the estuarine water are transported to the Gulf by the water flow.

The width of Shatt Al-Arab varies from 0.4 - 1.5 km along the 130 km reach from Basrah to the Gulf. The water depth of the main estuarine channel generally increases towards the Gulf, fluctuating between 7.5 m at Sindbad Island and 12.5 m near the mouth, although deeper regions are found where the estuary is narrow. The tides of the Gulf affect the water level of Shatt Al-Arab. The water from this estuary may reach Hor Hammar during the high tide and the brackish water from this Hor may enter into it during the ebb. The level of Shatt Al-Arab rises in Spring, due mainly to the rise in the levels of the Tigris and the Euphrates rivers during this season following melting of the snow in Turkey.

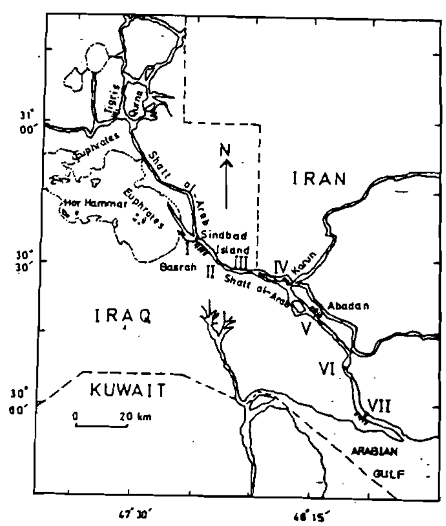

Fig. (1)
Map of Satt al-Arab showing the position of stations.

MATERIAL AND METHODS

Seven stations were selected to represent different regions of Shatt Al-Arab (Fig. 1). Sampling was carried out in January, April, August and October 1974 to represent winter, spring, summer and autumn, respectively. Three vertical samples were collected at each station, representing the surface, middle and bottom water. All surface samples were collected at a depth of about 20 cm to aviod floating matter. All samples were immediately treated with 0.5 % chloroform as a preservative, as proposed by Aberg and Rodhe (1942), in order to pevent or at least minimize changes and were kept in well stoppered polyethylene bottels. The samples were filtered and the dissolved inorganic nutrients were analysed spectrophotometrically. Nitrate, nitrite and phosphate were determined according to the methods described by American Public Health Association (1965) and the data are expressed in µg NO_3 1^{-1}, µg NO_2 1^{-1} and µg PO_4 1^{-1}, respectively. Silicate was determined according to Strickland and Parsons (1968) and the data are expressed in mg SiO_2 1^{-1}

RESULTS

a) Nitrate Content

The vertical distribution of dissolved nitrate is shown in Table 1 and the average values (averages of all depths at each station) in Fig. 2. In January and April, nitrate was generally deplteted in most samples of stations I, II and VI. The concentrations of nitrate increased or decreased with depth or showed irregular vertical variation during the investigation.

Considerable local variations were exhibited by the average nitrate values during all seasons. An extremely wide range of variation was encountered throughout the study period, as shown from the absolute minimum average value of 32.5 µg 1^{-1} at station I in October and the absolute maximum average value of 1893.1 µg 1^{-1} at station IV in April. As shown in Fig. 4, the regional average nitrate values increased considerably along the upper reach of the estuary from a minimum of 71.6 µg 1^{-1} at station I reaching a maximum of 1160.7 µg 1^{-1} at station IV, and were relatively high at stations V and VI.

In general, the average nitrate values showed considerable seasonal variations at each station. The seasonal average values fluctuated between 301.3 µg 1^{-1} in August and 738.8 µg 1^{-1} in January (Fig. 5). The average nitrate value obtained from Shatt Al-Arab during the study was 560.7 µg 1^{-1}

TABLE 1

Seasonal and regional variations of Nitrate (µg NO_3 l^{-1}) and Nitrite (µg NO_2 l^{-1}) in Shatt El-Arab during 1974.

Stations	Average Station depth (m)	Depth of samples (m)	Nitrate				Nitrite			
			January	April	August	October	January	April	August	October
I	7.5	0	00	513.9	53.2-	35.4	32.9	13.2	26.3	39.5-
		4	00	00	53.2-	44.3	13.2-	13.2	26.3	52.6
		7	0.0	0.0	141.8	17.7-	32.9	11.5-	23.0-	52.6
II	10.5	0	0.0	0.0	141.8	26.6	52.6	14.4	26.3	46.1
		4	0.0	0.0	141.8	115.2	19.7	14.4	29.6	46.1
		10	2144.1-	248.1-	141.8	292.4	52.6	14.4	26.3	46.1
III	11.5	0	265.8-	0.0	407.6	788.5	98.7	13.2	29.6	138.2+
		6	265.8-	248.1-	499.2+	000	98.7	13.2	29.6	131.6
		9	1594.8	735.4	496.2	699.9	98.7	13.2	29.6	138.2+
IV	7.0	0	1789.7	2303.6	319.0	877.1	118.4	32.9	26.3	72.4
		3	992.3	1692.3	496.2	877.1	118.4	26.3	26.3	72.4
		6	2055.5	1683.4	186.1	655.6	118.4	32.9	59.2	72.4
V	12.0	0	2436.5+	505.0	319.0	265.8	98.7	19.7	26.3	65.8
		5	699.9	0.0	496.2	575.9	105.3	13.2	26.3	65.8
		10	637.9	531.6	407.6	1063.2	121.7+	32.9	32.9	65.8
VI	12.0	0	416.4	0.0	484.8	1169.5	85.5	26.3	26.3	52.6
		5	0.0	0.0	319.0	1568.2+	105.3	19.7	26.3	52.6
		10	0.0	2542.8+	319.0	1568.2+	105.3	19.7	32.9	52.6
VII	12.5	0	-	-	-	-	19.7	39.5+	72.4	59.2
		4	-	-	-	-	32.9	32.9	79.0	59.2
		8	-	-	-	-	46.1	26.3	98.7+	72.4

The maximum values are designated by (+) and the minimum by (-).

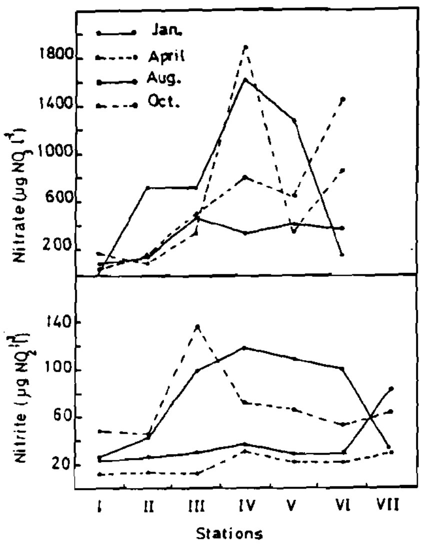

Fig. (2)
Seasonal variations of the average values of nitrate and nitrite in Shatt al-Arab during 1974.

b) Nitrite Content

Variations of dissolved nitrite content with depth are given in Table 1 and the average values of all depths at each station in Fig. 2. At one station (VII), the values increased with depth in January and August and decreased towards the bottom in April. The vertical nitrite values at the rest of stations were either irregular or similar. In October, the values at the three depths remained constant at four stations (II, IV, V, VI), but they were irregular or increased with depth at the others.

In general, the average nitrite values showed pronounced local variations in each season. The average nitrite values varied considerably during the investigation from an absolute minimum of 12.6 µg l^{-1} at station I in April to an absolute maximum of 136.0 µg l^{-1} at station III in October. the regional average nitrite values fluctuated between 28.1 µg l^{-1} at station I and 69.4 µg l^{-1} at station III. This maximum was generally followed by a slight decrease along the rest of staions (Fig. 4).

The average values of nitrite generally showed remarkable seasonal variations at each station. The highest average values were found in January and October at all stations except station VII. The seasonal average values ranged from 21.1 $\mu g\ l^{-1}$ in April to 75.0 $\mu g\ l^{-1}$ in January (Fig. 5). The average nitrite values found in Shatt Al-Arab during the study period amounted to 50.6 $\mu g\ l^{-1}$.

c) Phosphate Content

The concentrations of dissolved phosphate at different depths are shown in Table 2 and the average values (averages of all depths at each station) in Fig. 3. In April, phosphate was depleted in all samples, except at the surface, middle and bottom of stations IV, II and VI, respectively. The increase in phosphate values with depth occurred at some stations (II, IV, V and VII) in January and several places (III, IV, V and VI) in October. However, the vertical values showed irregular variations at most stations in August. A decrease in values towards the bottom was noticed at two stations (I in August and October; II in October) in these seasons and the irregular variations appeared at two places (III and VI) in january.

The average values of phosphate generally showed pronounced local variations in each season. A wide range of variation was found during the study period. The absolute minimum average values was 51.7 $\mu g\ l^{-1}$ at station III in August and the absolute maximum average value reached 498.3 $\mu g\ l^{-1}$ at station V in January. The regional average values of phosphate varied from a minimum of 92.1 $\mu g\ l^{-1}$ at station II to a maximum of 205.0 $\mu g\ l^{-1}$ at station V. the regional averages at stations IV and VI were markedly high, whereas that at station VII was noticeably low (Fig. 4).

The average concentrations of phosphate showed marked seasonal variations at each station. The seasonal average values ranged from 48.1 $\mu g\ l^{-1}$ in April to 186.2 $\mu g\ l^{-1}$ in October. The seasonal average value in January was markedly high (Fig. 5). The average value of phosphate found in Shatt Al-Arab throughout the study period was 129.4 $\mu g\ l^{-1}$.

d) Silicate Content

the concentrations of dissolved silicate at various depths are shown in Table 2 and the average values of all depths at each station in Fig. 3. In January and April, the values at some stations generally increased with depth or showed irregular vertical variations. The concentrations in August and October decreased towards the bottom at some stations and were constant at three places (I, IV and V) in October.

Local variations of the average silicate concentrations during all seasons

TABLE (2)

Seasonal and regional variations of phosphate ($\mu g\ PO_4\ l^{-1}$) and silicate ($mg\ SiO_2\ l^{-1}$) in Satt al-Arab during 1974.
Seasonal and regional variations of phosphate ($\mu g\ PO_4\ l^{-1}$) and silicate ($mg\ SiO_2\ l^{-1}$) in Satt al-Arab during 1974.

Stations	Depth of samples (m)	Phosphate				Silicate			
		Jan.	April	Aug.	Oct.	Jan.	April	Aug.	Oct.
I	0	60	00	370+	230+	4.28	7.49	8.99	7.70
	4	50	00	255	215	4.28	6.85	8.99	7.70
	7	50	00	35	210	4.28	7.06	9.13	7.70
II	0	50	00	60	200	4.49	8.03+	8.99	7.87+
	4	65	260	45	155	3.96	6.85	9.00	7.81+
	10	70	00	65	135-	4.07	7.49	9.00	7.70
III	0	190	00	20-	150	3.00	5.35-	9.00	7.81
	6	75	00	80-	155	3.21	5.78	8.99	7.70
	9	310	00	55	180	4.49	7.70	9.00	7.81
IV	0	40	560+	240	140	3.75	5.99	8.88	7.17
	3	85	00	95	145	4.28	6.21	8.77	7.17
	6	230	00	170	4.28	6.85	8.67	7.17	
	0	285	00	150	175	4.07	6.31	8.67	7.06
	5	600	00	115	190	4.49	5.56	8.77	7.06
	10	610+	00	140	195	4.07	6.85	8.67	7.06
VI	0	210	00	90	190	4.76+	7.49	8.67	6.85
	5	260	00	95	205	3.53	6.53	8.56	6.85
	10	105	190-	65	230+	4.07	5.99	8.56	6.63
VII	0	30-	00	90	210	1.61-	6.42	7.81	6.63
	4	65	00	120	215	1.93	6.21	7.38	6.63
	8	140	00	45	215	3.10	6.21	6.53-	6.42-

The maximum values are designated by (+) and the minimum by (-).

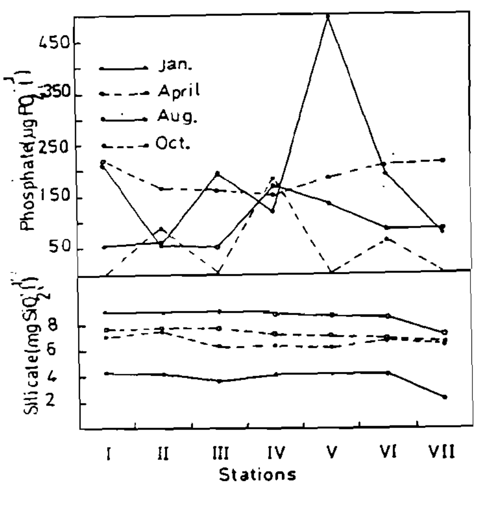

Fig. (3)
Seasonal variations of the average values of phosphate and silicate in Shatt al-Arab during 1974.

were noticeable. The average silicate concentrations showed a considerable wide range of variation throughout the investigation, as illustrated by the abosolute minimum average value of 2.21 mg l^{-1} at station VII in January and the aboslute maximum average value of 9.04 mg l^{-1} at station I in August. The regional average silicate values generally showed a slight decrease in the direction of the Gulf, from a maximum of 7.11 mg l^{-1} at station II to a minmimum of 5.57 mg l^{-1} at station VII (Fig. 4).

The average concentrations of silicate showed noticeable seasonal variations at each station. The seasonal average values varied from 3.81 mg l^{-1} in January to 8.62 mg l^{-1} in August with April and October values closer to the August maximum (Fig. 5). The average silicate value obtained from Shatt Al-Arab during the investigation reached 6.58 mg l^{-1}

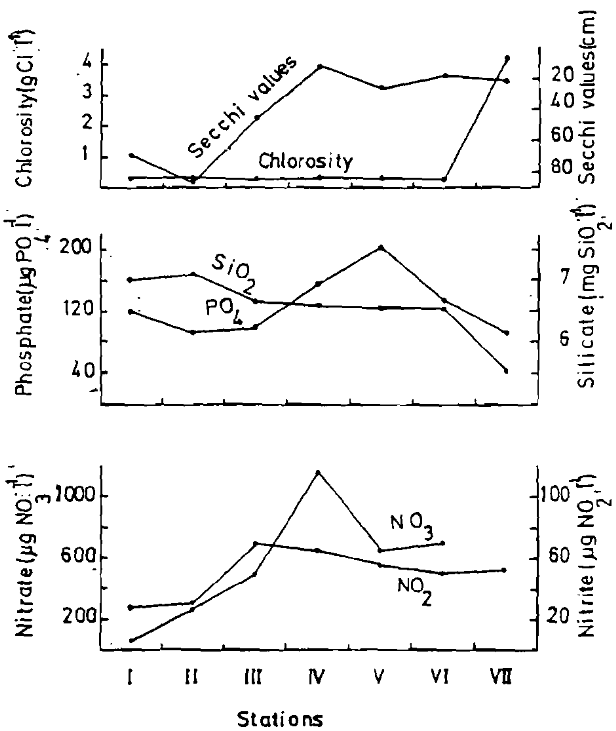

Fig. (4)

Variations of the regional average values (averages of all seasons at each station) of nutrients, chlorosity and Secchi readings in Shatt al-Arab during 1974.

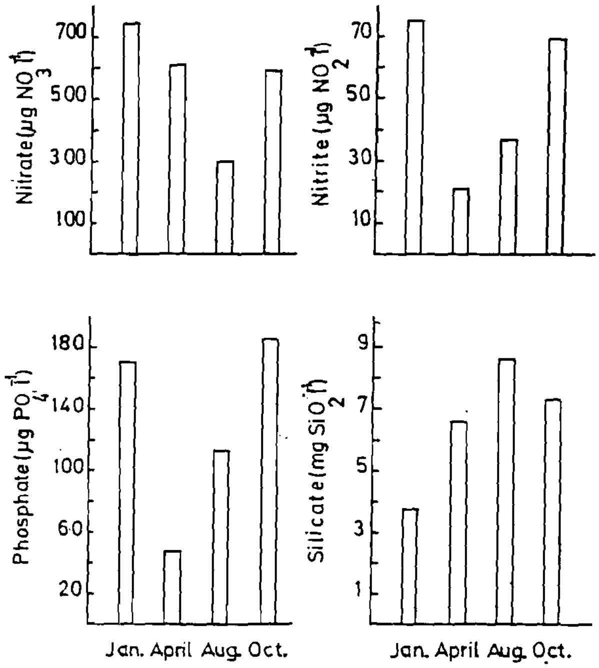

Fig. (5)
Variations of the seasonal average values (averages of all stations in each season) of nutrients in Shatt al-Arab during 1974.

DISCUSSION

a) Nitrate Variations

Nitrate depletion in the majority of samples of stations I, II and VI in January and April is due mainly to adsorption of a considerable part of nitrate on the suspended silt and clay particles which increased in these months (SAAD, 1978 a). Such depletion could be also attributed to the increase in the rate of nitrate consumption by phytoplankton in the euphotic zone (HANNAN and YOUNG, 1974) and nitrate reduction near the bottom (HUSSAINY, 1967). However, the high nitrate values found mainly at station III-V in those months are due to the input of remarkably high amounts of nitrates from the industrial wastes discharged from a large nitrogen fertilizer factory near location III and from the river karun opening into Shatt Al-Arab near station IV. The decrease or increase in nitrate content with depth, as well as the irregular vertical variations might probably be related to certain conditions occuring throughout the investigation (SAAD and ANTOINE, 1978 a). The increase in nitrate concentrations, especially in the bottom water, is due principally to the discharge of sewage and industrial wastes as well as the waters of the feeding rivers mainly karun, agricultural runoff (CASEY, 1975), increase in decomposition of organic matter mainly at or near the bottom (SAAD and ANTOINE, 1978 a) and regeneration of nitrate from the suspended and bottom material (SOLTERO et al ., 1974).

The average nitrate values showed noticeable local variations in each season. These are due possibly to the regional conditions responsible for increasing or decreasing the nitrate concentrations in the different depths of the estuary. The maximum average nitrate values found at station IV in January and April reflect the direct effect of the karun on this station. This was more pronounced in April due to the flood of this river. The considerable increase in the regional values of nitrate from station I - IV is due mainly to the input of nitrate from the polluted canals crossing Basrah during the ebb, industrial wastes of the fertilizer factory, discharge of the karun and agricultural runoff. The nitrate enriched estuarine water is transported to the Gulf by the water flow, as indicated by the relatively high regional average nitrate values at the downstream stations V and VI.

b) Nitrite Variations

Unilike nitrate, nitrite was detected in all vertical samples. The increase or decrease in nitrite concentration with depth, as well as the irregular vertical variation seem to be related to certain conditions found during the study period (SAAD and ANTOINE, 1978 a). The relative increase in nitrite content, particularly in the bottom samples, is attributed mainly to the discharge of sewage and industrial wastes as well as karun water, increase in nitrification of free ammonia to nitrite (MUNAWAR, 1970; SEENAYYA, 1971) and reduction of nitrate to nitrite (EL-WAKEEL and WAHBY, 1970; SEENAYYA, 1971).

The pronounced local variations of the average nitrite values generally found in each season coincided possibly with the regional conditions causing the increase or decrease in the nitrite content in the various estuarine water layers. The minimum regional average nitrite value found at station I is due mainly to its position far away from pollution effect and the uptake of nitrite by phytoplankton which was relatively abundant at this location where the average Secchi reading was high (Fig. 4) HUSSAINY (1967) stated that phytoplankton possibly utilizes all available nitrogen present in the water. The maximum and high regional average nitrite values found at stations III and IV (Fig. 4) relflect the direct effect of the waste outfalls from the fertilizer factory and the discharge of karun, respectively. As in case of nitrate, the relatively nitrite enriched water is transported to the Gulf, as shown from the high regional average nitrite values at the lower reach stations V, VI and VII (Fig. 4).

The average nitrate: nitrite ratio for the estuarine water was computed and is given in Table 3, in order to show the relationship between these two nutrients. This ratio varied from 0.7 : 1 at station I in October to 61.7 : 1 at station IV in April. The lowest ratio resulted from the absolute minimum average nitrate value (32.5 $\mu g\ l^{-1}$) and the relatively high average nitrite concentration (48.2 $\mu g\ l^{-1}$). The highest ratio is produced by the absolute maximum average nitrate value (1893.1 $\mu g\ l^{-1}$) and the low average nitrite value (30.7 $\mu g\ l^{-1}$). The ratio supports the supposition that the largest portion of inorganic nitrogen in Shatt Al-Arab is in the form of nitrate, provided that ammonia concentrations are not taken into consideration. This is in agreement with average nitrate: nitrite ratio for the Tigris (SAAD and ANTOINE, 1978 a).

Table (3)

Seasonal and regional variations of the average nitrate: nitrite ratio and average nitrate: phosphate ratio in Shatt al-Arab during 1974.

Stations	Averages	Average nitrste : nitrate ratio				Average nitrate : phosphate ratio			
		Jan.	April	Aug.	Oct.	Jan.	April.	Aug.	Oct.
I	7.5	-	13.6:1	3.3:1	0.7:1	-	-	0.4:1	0.2:1
II	10.5	17.2:1	5.7:1	5.2:1	3.1:1	11.6:1	1.0:1	2.5:1	0.9:1
III	11.5	7.2:1	24.8:1	15.8:1	3.7:1	3.7:1	-	9.1:1	3.1:1
IV	7.5	13.6:1	61.7:1	9.0:1	11.1:1	13.6:1	10.1:1	2.0:1	5.3:1
V	12.0	11.6:1	15.8:1	14.3:1	9.7:1	2.5:1	-	3.0:1	3.4:1
VI	12.0	1.4:1	38.7:1	13.1:1	27.3:1	0.7:1	13.4:1	4.5:1	6.9:1

c) Phosphate Variations

Depletion of phosphate at the vertical depths of all stations in April, except in three samples, is attributed principally to adsorption of large quantities of phosphate on the suspended silt and clay particles, which increased during the flood season (SAAD, 1973), as well as the increase in consumption by phytoplankton in the euphotic zone (SAAD, 1973). In spite of the considerable increase in the values of suspended matter in January (SAAD, 1978 a) and consequently the corresponding increase in phosphate quantity adsorbed on the silt, the concentrations obtained in this month were markedly high. These high values originated mainly from land runoff during the rainy season (SAAD and ANTOINE, 1978 a). The vertical variations of phosphate, appeared as increase or decrease with depth and sometimes showed irregular pattern, may be related to conditions encountered during the investigation. The markedly high phosphate concentrations found in the bottom samples at several locations in January and October might be due mainly to the decay of phytoplankton (HAMMER, 1971; SAAD, 1973), regeneration of large amounts of phosphate from the bottom deposits, a process that may be accelerated by water currents (MUNAWAR, 1970; SOLTERO et al ., 1974), excretion of considerable amounts of phosphate by aquatic organisms (SAAD and ANTOINE, 1978 a), sewage wastes (HAMMER, 1971; HANNAN and YOUNG, 1974) and runoff from cultivated land on both sides of the estuary (HAMMER, 1971; SAAD, 1973).

The regional conditions responsible for increasing or decreasing the phosphate content in the various water layers of the estuary probably caused the pronounced local variations of the average phosphate values in each season. The absolute maximum average value found at station V in January is attributed mainly to the increase in phosphate release from the sediments by stirring up of the bottom material due to the increase in the water current induced from wind action in winter. This is indicated by the remarkable high phosphate values in the bottom and middle water layers. The markedly high regional average phosphate value at station IV reflects the direct effect of Karun. However, the noticeably low regional average at station VII is attributed to dilution with the relatively phosphate poor Gulf water reaching this locality (Saad, 1978 a).

The average nitrate : phosphate ratio for the water of Shatt Al-Arab was computed (Table 3). This ratio ranged from 0.2:1.0 at station I in October to 13.6:1.0 at station IV in January. The lowest ratio resulted from the absolute minimum average nitrate value during a period of maximum average phosphate concentration (218.3 $\mu g\ l^{-1}$). The highest ratio is due to the maximum average nitrate value (1612.5 $\mu g\ l^{-1}$) and the relatively low average phospgate value (118.3 $\mu g\ l^{-1}$). One may conclude that nitrate was not a limiting nutrient. However, nitrate was generally considered as a limiting nutrient in the Tigris, as indiacted from the average nitrate: phosphate ratio, ranging from 0.01: 1- 7.90: 1 (Saad and Antoine, 1978 a). The high nitrate : phosphate ratio in Shatt Al-Arab compared with that in the Tigris, one of its feeding rivers, illustrates the allochthonous influx of nitrate mainly from sewage and industrial pollution as well as land runoff.

d) Silicate Variations

Silicate is of great importance as a major nutrient for diatoms (Hutchinson, 1957). The increase or decrease in silicate content with depth, as well as the irregular vertical variations are related to conditions existed during the investigation. The increase in silicate content, especially in the bottom water at some locations, is attributed mainly to decline of diatoms (BaileyWatts, 1976) and the increase in the rate of dissolution of diatom frustules and their fragments in the bottom sediments (Saad, 1975, 1976; Bailey-Watts, 1976). The decrease in silicate concentrations is due principally to uptake by diatoms (Seenayya, 1971, Saad and Antoine, 1978 a).

The noticeable local variations of the average silicate values in each season are related mainly to the regional conditions responsible for the relative increase or decrease in silicate content at different stations. The lowest average silicate values found in January, August and October at station VII are due mainly to dilution with the relatively silicate poor Gulf water reached this location (Saad, 1978 a). As shown in Fig. 3, the silicate content increased markedly at the begining of the flood period (April), reaching maximum average values at all stations in August. The effect of flood on the concentration of silicate decreased in October, reaching minimum average values at the individual stations in January. The slight decrease in the regional average silicate values to wards the Gulf is mainly related to the relative increase in uptake According to Kell and Saad (1975), the diatom density in April at stations I and II was generally lower than that at station III-VI.

The silicate content in Shatt Al-Arab was noticeably lower than that found by Saad and Antoine (1978 a) in the Tigris, one of its feeding rivers, this could be explained by three main factors. The first is dilution of the Tigris water with that of the Euphrates branch at Qurna, which contains relatively low concentrations of silicate (Saad, 1982). The second is the uptake of silicate from the other branch of Euphrates traversing Hor Hammar, due to the relative abundance of diatoms under favourable conditions, as indicated by the relatively lower silicate value obtainted from the water of this branch leaving Hor Hammar to join Shatt Al-Arab (Saad, 1982). However, further investigations on the silicate content of this branch are needed to throw out more light on this problem. The third factor is the increase in uptake of silicate in Shatt Al-Arab by diatoms, which were found in higher number than in the Tigris. According to Kell and Saad (1975), the diatoms in Shatt Al-Arab constitute 68% of the total cell numbers of phytoplankton in April. However, the percentage of diatoms in the Tigris gave 60.35, 32.21 and 48.74% in January, April and July, respectively (Saad and Antoine, 1978 b). In April, the diatom percentage in the Tigris was less than hlaf that in Shatt Al-Arab.

Based on variations of the average pH values in Shatt Al-Arab, Saad (1978 a) pointed out that phytoplankton density decreased in January and April. Mainly as a result of the increase of water current and turbidity and was abundant in August and October in better environmental conditions. This seasonal distribution of phytoplankton in Shatt Al-Arab was not generally accompanied by the corresponding seasonal variations of nutrients. Accordingly, uptake of nutrients by phytoplankton could not be considered as a mian factor affecting the nutrient content in Shatt Al-Arab. This conclusion is supported by the great decrease in the depth of euphotic zone and consequently the corresponding decrease in photosynthetic activity along the estuarine section from station III - VII, as shown from the considerably low regional average Secchi values in Fig. 4 (Saad, 1978 a). However, other nonbiological factors seem to play a large role in affecting the concentrations of nutrients in Shatt Al-Arab. These are mainly the industrial wastes from the fertilizers factory, discharge from the feeding rivers mainly Karun, input from the polluted waters of the canals crossing Basrah during the ebb and agricultural runoff.

SUMMARY

Water samples were collected from Shatt Al-Arab, the Euphrates and Tigris estuary, to the seasonal distribution of nutrients. Depletion of nitrate in January and April is attributed mainly to adsorption of large amounts of nitrate on the suspended particles, which increased in these months, as well as the increase in the rate of nitrate uptake and its reduction. The high nitrate content is due mainly to the discharge of sewage and industrial wastes as well as the waters of the feeding rivers mainly Karun, agricultural runoff, increase in decomposition of organic matter and regenration of the adsorbed nitrate.

Nitrite was detected in all samples. The increase in nitrite concentration is attributed principally to the discharge of sewage and industrial wastes as well as Karun water, increase in nitrification of free ammonia to nitrite and reduction of nitrate to nitrite. The average nitrate : nitrite ratio, ranging from 0.7:1.0 to 61.7:1.0, demonstrates that the larger portion of inorganic nitrogen in Shatt Al-Arab is normally nitrate.

Depletion of phosphate in April is due mainly to adsorption of considerable quantities of phosphate on the suspended particles and the increase in uptake by phytoplankton. The markedly high phosphate concentartions found in January, in presence of considerable high values of suspended matter, originated mainly from land runoff during the rainy season. The remarkable high phosphate concentrations found in some bottom samples coincided principally with the decay of phytoplankton, release of considerable amounts of phosphate from the sediments, sewage wastes and runoff from cultivated land.

The increase in silicate values, especially in the bottom samples at some locations, is due principally to decline of diatoms and the increase in the rate of dissolution of diatom frustules in the sediments. The low average silicate values found at station VII are due mainly to dilution with the relatively silicate poor Gulf water reached this locality. The slight decrease in the regional average silicate values towards the gulf is mainly related to the relative increase in uptake.

It was concluded that uptake of nutrients by phytoplankton could not be considered as a main factor affecting the nutrient content in Shatt Al-Arab. However, other nonbiological factors seem to greatly affect the concentrations of nutrients.

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